



UNIVERSITI PUTRA MALAYSIA

**DEGREENING CHARACTERISTIC OF MUSA AAA 'BERANGAN' AND
"WILLIAM CAVENDISH' BANANAS**

PHEBE DING.

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By

PHEBE DING

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DEGREENING CHARACTERISTICS OF *MUSA* AAA 'BERANGAN' AND 'WILLIAM CAVENDISH' BANANAS

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Chairman: Associate Professor Siti Hajar Ahmad, Ph.D.

Faculty: Agriculture

A study was conducted on the changes in cellular structure, physiology and physiochemical of *Musa* AAA 'Berangan' and 'Cavendish' as the ripening progressed at 18 ± 2 and 27 ± 2 °C. Mature green (ripening stage (RS) 1) bananas were initiated to ripen using 0.02% acetylene from calcium carbide (CaC_2) source (with an equivalent of 1 g CaC_2 .kg⁻¹ fruit) for 24 h. A hand of Berangan and Cavendish fruit was split into 2 clusters. One of the clusters was initiated and ripened at 18 ± 2 °C RH 90-94%, while the other was initiated and ripened at 27 ± 2 °C RH 75-80%. The experiment was conducted using randomized complete block design with four replications. Five fruits per replicate were used. The various ripening stages were evaluated with the aid of FAMA visual colour score until the fruit turned into full yellow at RS 6. For the Cavendish ripened at 27 ± 2 °C (C27) where the fruit failed to degreen, the evaluation was done daily until senescence, when brown specks appeared on the peel. Data from measurements of ripening duration, L^* , C^* and h° values, chlorophyll *a*, *b* and total chlorophylls, water loss, stomatal density, stomatal

length and opening, peel thickness, peel and pulp fresh and dry weight, cell length and width of photosynthetic, epidermal, crystalliferous, tanniferous and starch granules, pulp firmness, soluble solids concentration (SSC), titratable acidity and pH were analysed using analysis of variance and differences between means were determined by Duncan Multiple Range Test. Data from starch iodine test, cellular structure and ultrastructure were documented as photographs or micrographs. Berangan degreened naturally under tropical ripening temperature of 27 ± 2 °C, and a golden yellow fruit of RS 6 was obtained within 4 d of ripening. In contrast, Cavendish failed to degreen at 27 ± 2 °C even though the pulp had softened. By day 5 after the acetylene treatment brown specks started to appear on the fruit surface indicating senescence had commenced. Cavendish could only degreen when ripened at 18 ± 2 °C, and a yellow fruit of RS 6 was obtained after 9 d of ripening. On the contrary, Berangan could not degreen and ripen under 18 ± 2 °C thus the fruit was discarded. TEM revealed that at RS 6 the grana-thylakoid membrane of chromoplast Berangan ripened at 27 ± 2 °C (B27) and Cavendish ripened at 18 ± 2 °C (C18) had lysed. Besides, plastoglobuli increased in number, and types of staining density and vesicles increased in number and size. However at day 5 of C27, the grana-thylakoid membrane retained and this was in concurrent with the high retention of chlorophyll content in fruit peel. The total chlorophyll retained in C27 was 57%, while only 25 and 40% of total chlorophyll was retained in B27 and C18 respectively. The high retention of chlorophyll content in C27 had caused it to correlate significantly with L^* , C^* and h^0 values. Among B27, C18 and C27, C27 encountered the most water loss. However, there was no correlation between water loss and stomatal density and opening. The existence of cracks and pores on the banana peel surface could be the



passage for water loss. The severe water loss caused the peel thickness of C27 to be the thinnest among the bananas studied although initially its peel was thicker than B27. The fruit pulp and peel behaved differently towards ripening temperature. The moisture content in pulp increased, while no moisture content in peel decreased as ripening progressed. This led to increase of pulp to peel fresh weight ratio and C27 had the highest ratio as compared to C18 and B27. The softening of the banana fruit was due to starch degradation and dissolution of middle lamellae. SEM revealed that the pulp starch granules decreased in size and density as ripening progressed. The blue-black stained area of starch-iodine complex cleared from the central core of fruit towards the periphery of peel in all the bananas studied. The clearing pattern was most rapid in C27. The hydrolysed starch increased the SSC of all the bananas studied but the most significant increase was in C27. The titratable acidity of the three bananas studied increased then decreased as ripening progressed. In contrast, the pH decreased then increased as contrary to the trend of titratable acidity. The tropical temperature of 27 ± 2 °C, besides failing to degreen, had caused poor keeping and eating quality of Cavendish.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**PENCIRIAN PENYAHHIJAUAN PADA PISANG, *MUSA* AAA
'BERANGAN' DAN 'WILLIAM CAVENDISH'**

Oleh

PHEBE DING

Mac 2004

Pengerusi: Profesor Madya Siti Hajar Ahmad, Ph.D.

Fakulti: Pertanian

Suatu kajian dijalankan ke atas perubahan struktur sel, fisiologi dan fiziko-kimia semasa proses kemasakan pada *Musa* AAA 'Berangan' dan 'Cavendish' yang diranumkan pada suhu 18 ± 2 dan 27 ± 2 °C. Pisang yang hijau matang (Peringkat Kematangan (PK) 1) diperam dengan menggunakan 0.02% asetilena yang dibebaskan dari sumber kalsium karbida (CaC_2) (bersamaan dengan 1 g CaC_2 .kg⁻¹ buah) selama 24 j. Sesikat Berangan dan Cavendish dipisahkan kepada dua bahagian. Salah satu bahagian diperam dan diranum pada suhu 18 ± 2 °C dengan kelembapan relatif (RH) 90-94%. Manakala bahagian yang lain diperam dan diranum pada suhu 27 ± 2 °C RH 75-80%. Ujikaji dijalankan dengan menggunakan rekabentuk blok rawak lengkap dengan empat replikasi. Sebanyak lima biji buah/replikasi digunakan. Penilaian dibuat berdasarkan peringkat kemasakan dengan Panduan Carta Warna FAMA sehingga buah mencapai kuning sepenuhnya pada PK 6. Untuk buah Cavendish yang diranum pada suhu 27 ± 2 °C (C27) di mana buah gagal menyahhijau, penilaian dijalankan setiap hari sehingga senesens di mana

bintik perang kelihatan pada kulit buah. Data-data masa peranakan, nilai-nilai L^* , C^* dan h° , klorofil a , b dan jumlah klorofil, kehilangan air, ketumpatan stomata, panjang dan lebar stomata, ketebalan kulit, jisim segar dan kering kulit dan isi, panjang dan lebar untuk sel-sel fotosintetik, epidermis, 'crystalliferous' dan 'tanniferous' dan butiran kanji, kekerasan isi, jumlah kandungan pepejal terlarut, asid tertitrat dan pH dianalisa dengan menggunakan kaedah analisis varian dan perbezaan antara setiap min ditentukan dengan menggunakan kaedah 'Duncan Multiple Range Test'. Data ujian iodine terhadap kanji, struktur dan ultrastruktur sel dicatatkan sebagai gambar foto atau mikro. Berangan dapat menyahhijau secara semula jadi di bawah suhu tropikal pada $27 \pm 2^\circ\text{C}$ dan buah kuning keemasan diperolehi selepas 4 hari peranakan. Sebaliknya Cavendish tidak dapat menyahhijau pada suhu $27 \pm 2^\circ\text{C}$ sungguhpun isinya sudah lembut. Pada hari ke-5 selepas dirawat dengan dengan asetilena, bintik perang mulai kelihatan pada kulit buah yang menandakan bermulanya senesens. Cavendish hanya boleh dinyahhijau apabila diranum pada suhu $18 \pm 2^\circ\text{C}$ dan buah berwarna kuning penuh pada PK 6 selepas 9 hari diranum. Sebaliknya Berangan tidak dapat dinyahhijau dan masak pada suhu $18 \pm 2^\circ\text{C}$. Penemuan melalui TEM mendapati pada PK 6, membran grana-tilakoid pada kromoplast Berangan yang diranum pada $27 \pm 2^\circ\text{C}$ (B27) dan Cavendish yang diranum pada suhu $18 \pm 2^\circ\text{C}$ (C18) sudah lisis. Selain itu, bilangan dan jenis darjah kepekatan pewarnaan elektron plastoglobuli bertambah dan bilangan dan saiz vesikel juga bertambah. Tetapi, pada hari ke-5, membran grana-tilakoid C27 masih kelihatan dan ini adalah sejajar dengan pengekalan kandungan klorofil yang tinggi pada kulit buah. Jumlah klorofil yang masih wujud pada C27 adalah 57% sementara hanya 25 dan 40% jumlah klorofil yang tinggal pada B27 dan

C18 masing-masing. Pengekalan kandungan klorofil yang tinggi di dalam C27 telah menyebabkan kandungan klorofil berkolerasi bererti dengan nilai-nilai L^* , C^* dan h° . Di kalangan B27, C18 dan C27, C27 mengalami kehilangan air yang paling banyak, tetapi tiada kolerasi di antara kehilangan air dengan ketumpatan dan pembukaan stoma pada kesemua pisang yang dikaji. Kewujudan retak dan lubang pada permukaan kulit pisang mungkin merupakan laluan untuk kehilangan air. Kehilangan air yang teruk mengakibatkan ketebalan kulit C27 menjadi paling nipis di kalangan pisang yang dikaji walaupun ketebalan kulitnya pada peringkat permulaan adalah lebih tebal daripada B27. Kelakuan isi dan kulit buah terhadap suhu peranakan adalah berlainan. Kelembapan kandungan pada isi bertambah, manakala kelembapan kandungan kulit berkurangan semasa proses peranakan. Ini mengakibatkan nisbah jisim segar isi kepada kulit bertambah dan C27 mempunyai nisbah yang paling tinggi jika berbanding dengan C18 dan B27. Kelembutan isi buah pisang disebabkan oleh penguraian kanji dan lamela tengah. Penemuan dari SEM mendapati saiz dan ketumpatan butiran kanji pada isi berkurangan semasa proses peranakan. Kawasan biru kehitaman yang terhasil dari kompleks kanji-iodin luntur dari bahagian tengah buah dan berlanjutan sehingga periferi buah di kulit pada kesemua jenis pisang yang dikaji. Corak pelunturan adalah paling cepat pada C27. Kanji yang telah dihidrolisis meningkatkan kandungan jumlah pepejal terlarut dengan pertambahan yang paling bererti pada buah C27. Ketiga-tiga jenis pisang menunjukkan pertambahan asid tertirat, diikuti dengan pengurangan semasa proses peranakan. Sebaliknya, pH meningkat, kemudian menurun di mana pola perubahannya adalah berlawanan dengan asid tertirat. Akhir kata, suhu peranakan

tropikal pada 27 ± 2 °C selain menyebabkan kegagalan menyahhijau, ia juga telah menurunkan kualiti penyimpanan dan nilai pemakanan pada Cavendish.

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I certify that the Examination Committee have met on 25th March, 2004 to conduct the final examination of Phebe Ding on her Doctor of Philosophy thesis entitled “Degreening Characteristics of *Musa* AAA ‘Berangan’ and ‘William Cavendish’ Bananas” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommended that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

Gulam Rusul Rahmat Ali, Ph.D.

Professor
Faculty of Food Science and Biotechnology
Universiti Putra Malaysia
(Chairman)

Siti Hajar Ahmad, Ph.D.

Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Abdul Rahman Abdul Razak, Ph.D.

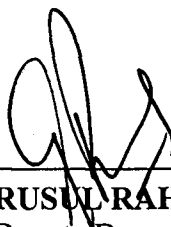
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Nazamid Saari, Ph.D.

Associate Professor
Faculty of Food Science and Biotechnology
Universiti Putra Malaysia
(Member)

Mahmud Tengku Muda Tengku Mohamed, Ph.D.

Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)



GULAM RUSUL RAHMAT ALI, Ph.D.

Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 30 JUN 2004

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirements for the degree of Doctor of Philosophy. The members of the Supervisory Committee are as follows:

Siti Hajar Ahmad, Ph.D.

Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Abdul Rahman Abdul Razak, Ph.D.

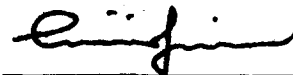
Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

Nazamid Saari, Ph.D.

Associate Professor
Faculty of Food Science and Biotechnology
Universiti Putra Malaysia
(Member)

Mahmud Tengku Muda Tengku Mohamed, Ph.D.

Associate Professor
Faculty of Agriculture
Universiti Putra Malaysia
(Member)

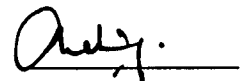


AINI IDERIS, Ph.D.
Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 09 JUL 2004

DECLARATION

I hereby declare that the dissertation based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been submitted for any other degree at UPM or other institutions.


PHEBE DING

Date: 22/5/04

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